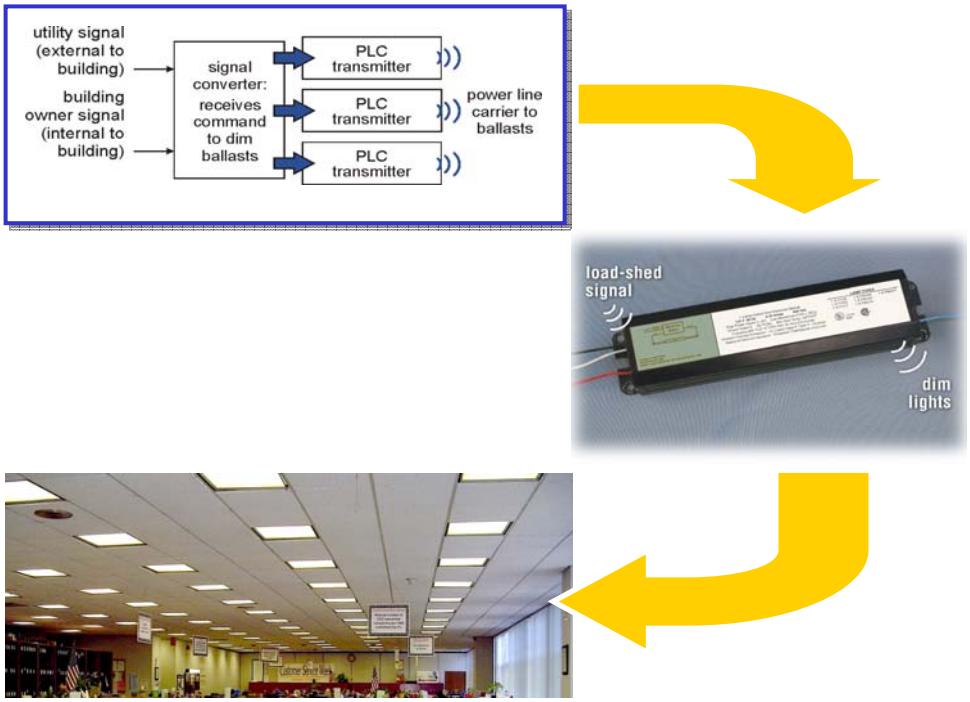
LIGHTING RESEARCH PROGRAM

Project 3.2 Load-Shedding Economic Analysis Report

FINAL REPORT



Consultant Report

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Energy Efficient Load Shedding Technology Economic Considerations

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TECHNOLOGY TRANSFER TEMPLATE DEVELOPED BY BEVILACQUA-KNIGHT, INC.

Energy Efficient Load Shedding Technology
Economic Considerations

The Energy Efficient Load Shedding Technology

There are two products that are included in the load shedding technology, a load shed ballast and a retrofit load shed device. These devices cost effectively reduce fluorescent lighting power requirements by a fixed percentage during times of high electric demand of the customer or electric system without sacrificing employee productivity.

Function and Features

The purpose of the load shed ballast is to replace existing instant start ballasts in new fluorescent lighting fixtures used in new construction or for commercial building remodeling. The retrofit device can be installed in existing fluorescent lighting fixtures that employee standard instant start ballasts. When a signal is received from a remote controller via power line carrier communications, the load shed ballast and/or the retrofit device will dim the fluorescent light fixture and reduce the lighting power demand by a fixed amount during periods of high electric demand.

Load Shed Ballast:

- Minimal to no effect on lamp life when used as a load management tool.
- Built on an instant start platform to allow for lowest possible cost and efficient operation.
- Has the same performance characteristics of an instant start ballast when not in the dimming mode.
- Has the same physical characteristics as an instant start ballast.
- Will be used usually to reduce electrical power demands for about 100 hours per year.
- Can replace an instant start ballast with no additional wiring.
- Receives a signal from an external controller to dim the lamps to a predetermined level and consequently reduces electric power requirements.
- Any failure of the load shed portion of the ballast will allow the lamps to operate at their full brightness.
- UL listed.

Load Shed Retrofit Device:

- Fits conveniently within existing fluorescent light fixtures.
- Easy to install with its clip-on wiring system.
- Does not disturb the performance characteristics of the fixture when not in the dimming mode.
- Uses less than 0.5 watts of additional power when not in the dimming mode.
- Minimal to no effect on lamp life when used as a load management tool.
- Will be used usually to reduce electrical power demands for about 100 hours per year.
- Receives a signal from an external controller to dim the lamps to a predetermined level and consequently reduces electric power requirements.
- Any failure of the retrofit device will allow the lamps to operate at their full brightness.
- UL listed.

Product Scenarios

The load shedding devices being developed by the Lighting Research Center fall into two distinct categories. The first is a load shed ballast comprised of an instant start ballast and circuitry to receive a signal from external sources and reduce lamp output and power input during times of customer or utility peak electric usage. All this added circuitry is contained within the ballast housing. This device will primarily be used in new commercial construction and in building renovation where the lighting fixtures are being replaced. It can also be used when a customer is replacing inefficient magnetic ballasts in existing lighting fixtures.

The second product is a retrofit load shed device that can be housed within the fluorescent light fixture and wired into the lamp circuit. It will receive a signal from external sources and reduce lamp output and power input during times of customer or utility peak electric usage. This device will primarily be used in existing commercial buildings and with existing energy efficient electronic ballasted fluorescent lighting fixtures.

The competition for both products is a load reduction device that can be fitted onto a lighting panel. These devices affect all lights and equipment that are connected into the panel. The potential for reducing electrical load using these panel devices is still being explored. The main disadvantage of these devices is all lights and any other equipment connected to the panel will be dimmed. The user cannot choose which lights to control. The load shed ballast and retrofit device are connected to each lighting fixture and will allow the customer to choose which lights to control. It does not require the lighting to be separately circuited from other building loads.

Supplier's Product Costs and Prices

The estimated cost to manufacture the load shed ballast is $2.75 above the cost of the instant start ballast. This incremental cost includes the load shedding and communication

circuitry. Using the standard rule of thumb of customer cost being three times manufacturing costs, the cost of the load shed ballast to the customer is estimated to be $8.25 above the cost of an instant start ballast.

The estimated manufacturing cost of the retrofit load shed device is $2.75. Using the same rule of thumb produces a customer cost of $8.25.

Both devices will require a controller to communicate with the ballasts or retrofit device. The controller is estimated to cost the customer $100.00. Each controller can communicate with all ballasts or retrofit devices located within a minimum of 10,000 square feet of the controller.

Customer's Installation-Related Costs

New Construction/Building Renovation
The load shed ballast would replace the standard instant start ballast normally found in fluorescent lighting fixtures. Since the physical dimensions and electrical connections are identical to existing ballasts, there are no incremental installation costs.

Retrofit
It is envisioned the retrofit load shed device can be installed by the building's maintenance staff because the device will just require clipping onto the light fixtures wires. Time required to complete installation is 15 minutes at a cost of approximately $10.00. This estimated cost was developed through discussions with an energy service company.

Effects on Non-energy Operations & Maintenance Costs

Tests to date indicate a slight reduction of less than 1 percent of lamp life due to dimming the lamps without providing heat to the lamp cathodes if the lamps are dimmed by approximately 30 percent for about 100 hours per year.

Energy and Demand Savings Potential

The load shed ballast and the retrofit device reduce demand during times of customer or utility peak electric loads. Each device will reduce demand approximately 30 percent of the connected fixture lighting load. Minimal energy savings is achieved. The table below indicates the demand reduction based on the number of lamps per lighting fixture.

T-8, Electronic Ballast, 2-lamp fixture	20 watts
T-8, Electronic Ballast, 3-lamp fixture	30 watts
T-8, Electronic Ballast, 4-lamp fixture	40 watts

Non-Energy Benefits to Customers

Research conducted at the Lighting Research Center indicates 80 percent of workers cannot detect a dimming condition of 20 percent if the dimming is performed over approximately 10 seconds. Further research showed workers were acceptable of 30 percent dimming if management explained the dimming was occurring to reduce the electrical loads. A 30 percent dimming limit will not affect the productivity of most office workers. Current practice when trying to reduce electric loads in offices is to turn off a series of light fixtures, which drastically reduces productivity. The benefit of the load shed ballast technology is its non-effect on worker productivity.

Societal Avoided Costs (for possible incentive payments)

Appendix 1 of this plan contains the full details of the developed avoided costs for the load shed ballast and the retrofit device. The total resource cost test was used in determining the avoided costs. Information on avoided costs was developed from the reports of Working Group 2 of the "Rulemaking on Policies and Practices for Advanced Metering, Demand Response and Dynamic Pricing" established by the California Public Utility Commission in Docket No. R.02-06-001.

The load shed ballast meets the avoided cost test and should be pursued. However, the retrofit device for existing fluorescent lighting fixtures fails to meet the avoided costs of utilities and customers and should not be promoted by utilities. i.e. Utility customers are better off by having the utility purchase power rather than use the retrofit device.

Based on the above, it is not recommended technology transfer efforts be pursued for the retrofit device.

Payback Period and Return on Investment

Customer savings for shedding lighting load either through a reduction in their monthly electric bill or participation in a utility emergency load shedding program appears to be approximately $3.50 per year per lighting fixture. The customer's incremental cost of the load shed ballast and its associated controller is estimated to be $9.00 per lighting fixture. This will provide a customer with a simple payback of 2.57 years. Any utility incentive will reduce the customer payback.

Customer savings for the retrofit device are the same as for the load shed ballast at approximately $3.50 per year per lighting fixture. The device is anticipated to cost approximately $9.00 per lighting fixture. However, an installation fee of approximately $10 per lighting fixture must be added to the retrofit device. Therefore, the simple payback to a customer is 5.4 years.

Sales and Energy Savings Volumes

The primary markets for the load shed ballast are new construction and remodeling of owner occupied office buildings and public buildings. The size of these markets nationally approaches 500,000 load shed ballast annually and 40,000 ballasts annually within California after a five year ramp up period. Demand reductions would increase by 15,000 kW nationally and 1,200 kW within California each year at the above sales estimates.

Other substantial markets exist for the load shed ballast but are not included as part of the technology transfer plan because of the difficulty or marketing costs to reach these markets. The commercial retail floor space is substantial. However, the primary business purpose of retail customers is to sell products from their stores. Dimming lights to save a minimum amount of money would not be acceptable if lost sales were encountered. Non-owner occupied office space is also substantial. However, the issue with installation of load shed ballasts is who pays for the installation and who reaps the benefits. This issue has been a systemic problem for many energy efficiency improvements in buildings and would definitely be present for the load shed ballast.

Market Segmentation, Size and Price Effects

The markets for the load shed ballast are segmented into new construction and building remodeling/renovation. It is further segmented into owner occupied office space and public buildings. The size of the national and California markets are developed from Energy Information Administration and census data. New construction is based on the percent non-farm job growth (2.3 percent in U.S., 2.0 percent in CA), which recognizes that people need space to work. Remodeling estimates are based on existing floor space replacing light fixtures every 15 years for offices and 25 years for public buildings.

Table 1: Market Size

Segment	U.S.	California
New Construction		
Owner Occupied Offices	138,000,000 s.f.	18,000,000 s.f.
Public Buildings	246,000,000 s.f.	24,000,000 s.f.
Remodeling/Renovation		
Owner Occupied Offices	820,000,000 s.f.	52,500,000 s.f.
Public Buildings	492,000,000 s.f.	42,000,000 s.f.

Market Size versus Annual Sales

Annual sales is a function of market penetration. Market penetration is directly affected by the acceptance of the load shed technology and marketing efforts. For purposes of this technology transfer plan, the LRC has assumed penetration rates that differ by year from the date of technology introduction and by market segment. It is believed momentum and acceptance of the new technology will build over time. Also acceptance within the

public building arena will be greater than within owner occupied office buildings. The following table presents the percentages of market penetration by year and by market segment.

Table 2: Market Penetration (as percent of total market)

	Offices	Public Buildings
Year 1	0.1%	0.5%
Year 2	0.5%	1.0%
Year 3	1.0%	2.0%
Year 4	2.0%	5.0%
Year 5	4.0%	8.0%

Annual sales nationally and within California are estimated based on the market size and penetration as stated above and that one ballast will be used for every 200 square feet of floor space. Based on this information and a demand reduction of 30 watts per ballast, Table 3 provides estimates of load shed ballast sales and demand reductions for the U.S. market and for California.

Table 3: Annual Sales and Demand Reductions

	U.S.		California	
	Sales	Demand Reduced	Sales	Demand Reduced
Year 1	23,240	697 kW	2,002	60 kW
Year 2	60,890	1,827 kW	5,062	152 kW
Year 3	121,700	3,651 kW	10,125	304 kW
Year 4	280,300	8,409 kW	23,550	707 kW
Year 5	487,000	14,610 kW	40,500	1,215 kW

The Buyer and Other Influencers

The buying decision makers are commercial building owners especially of owner/occupied and public buildings. The decision will occur normally during the building design process for new and remodeled buildings. Building occupants may also be considered buyers for the retrofit device if it meets their economic criteria.

Building designers (architects, consulting engineers and lighting designers) play an important role of informing and educating building owners of the value of including load shedding into the building's lighting scheme.

The Competition

The primary competitive product of the load shed ballast is a lighting panel dimming control. The estimated cost of the load shed ballast and panel dimming are comparable. With panel dimming, all lights associated with that lighting panel must dim. The load

shed ballast will allow the customer to select which light fixtures they wish to dim. Panel dimming, which is commercially available, is not currently experiencing any large sales volumes.

Uncertainties

This is a new and different technology. It needs the support of the utility industry to be successful. The utility industry needs assurances the technology works and has a value to customers and the utility. This can be achieved through the development and evaluation of demonstration sites. Another concern is the warranty of lamps being dimmed through an instant start ballast technology. Will lamp manufacturers invalidate their warranties? Discussions to date with the major lamp manufacturers indicates they are willing to stand behind their warranties as long as the load shed dimming hours are limited to approximately 100 hours per year.

Consumer Choice Barriers

The primary barrier is cost effectiveness. While the cost maybe well known, the benefits are uncertain from year to year. Each year will bring a different benefit from utilities or state run load management programs based on the amount of curtailment necessary for that year. A customer wants and needs certainty for the return on an investment like the load shed ballast. Uncertainty will cause many customers not to buy.

Appendix 1: Simplified Economic Analysis for the Load Shed Ballast

The economic analysis for the load shed ballast must be examined in two ways: first, what are the economic benefits for the end use customer and second, what are the avoided costs to the utilities and society in using the load shed ballast technology? This appendix explores both situations.

Customer Economic Analysis

I. Introduction

This analysis examines the customer cost savings if the load shed ballast technology was applied compared to the incremental cost of the ballast or retrofit device installed as part of a new construction/renovation project or retrofitted into existing buildings. The savings are expressed on a per light fixture/ballast basis. Firm, interruptible and load management rates of Southern California Edison (SCE), Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), Sacramento Municipal Utility District (SMUD) and Los Angeles Department of Water and Power (LADWP) were used to determine customer cost savings.

The customer cost for the retrofit device is estimated to be $9 and the load shed ballast has an incremental cost of $9 over an instant start ballast. These prices include the sharing of the cost for the signaling device. The installation cost of the retrofit device or the load shed ballast into an existing light fixture is estimated to be $10 per fixture. There is no incremental installation cost for a new light fixture with the load shed ballast installed and used in new construction or as part of a building's renovation.

II. Assumptions

For purposes of this analysis, the electrical customer is assumed to have a peak electrical demand of over 1,000 kW, be served at secondary voltages and the transformer is owned by the distribution utility. This allows for the selection of the appropriate electrical rates.

The light fixture to be controlled is assumed to be a three lamp, T-8, electronic ballast parabolic fixture that consumes 100 watts. A demand reduction using the load shed ballast or retrofit device of 30 watts is achievable.

The load shed device or ballast will operate for 100 hours per year during the customer's monthly peak demand periods and during the summer months only as defined by each utility. For interruptible or load management rates, the load shed ballast reduces load during the hours required by the rate. It is recognized that some of the rates used are either closed to new customers or the total requirements maybe beyond what can be achieved by reducing just the lighting load. These rates were

included here for illustrative purposes of what could be achieved if the rate could be used with the load shed ballast.

III. Customer Electrical Cost Savings

Action	Rate	Annual Savings Per Device
SCE		
Monthly Peak Demand Reduction	TOU-8	$3.48
Interruptible Rate	I-6-BIP	$2.52
Critical Peak Pricing Rate	TOU-8-CPP	pricing not available
PG&E		
Monthly Peak Demand Reduction	E-20S	$3.06
Interruptible Rate	E-BIP	$2.52
Demand Bidding	E-DBP	$1.05
Load Reduction	E-SLRP	$0.30
Critical Peak Pricing Rate	E-CPP	$3.96
SDG&E		
Monthly Peak Demand Reduction	AL-TOU	$3.08
Interruptible Rate	BIP	$2.52
Demand Bidding	DBP	$1.05
Load Reduction	SLRP	$0.30
Critical Peak Pricing Rate		pricing not available
SMUD		
Monthly Peak Demand Reduction	GS-TOU1	$1.51
Load Reduction	PowerNet	$0.75
LADWP		
Monthly Peak Demand Reduction	A-3, Rate C	$1.81
Real Time Pricing	XRT	$4.17

IV. Analysis

The focus group conducted with customers regarding load management programs and the load shed ballast indicated the primary reason for participation is a financial reward to the customer. The cost to participate must be recouped in a reasonable period of time. For purposes of this analysis, a reasonable period of time is defined as a three year simple payback of the customer's investment in the load shed ballast or retrofit device. It is recognized payback periods differ by type of customer and economic times.

Based on the above customer cost savings, only the load shed ballast installed in light fixtures used in new construction or building renovations would meet the three year

payback criteria. The installation cost of the retrofit device or a load shed ballast into an existing light fixture essentially doubles the payback period to six years. While six years maybe acceptable to municipal/state type facilities, it is not acceptable to most businesses.

There does exist some rebate programs sponsored by the California Energy Commission (CEC) that have the ability to offset some of the initial capital cost for the purchase and installation of the load shed ballast or the retrofit device. One program, "Bring Me a Watt", will pay up to $250 per kW of peak load reduction. This is equivalent to $7.50 per load shed ballast.

The CEC has identified exposing end use customers to real time electric prices as a priority in controlling electric peak loads. Congress, in the proposed Energy Policy Act 2003 legislation, has also placed emphasis on real time pricing for businesses. Real time prices could increase the economic advantage of the load shed ballast to the customer.

Utility Avoided Cost Test

I. Summary

The load shed ballast and retrofit device are demand reduction only devices and do not save much energy. Therefore, the use of the standard avoided cost values as prepared and approved by the California Public Utility Commission (CPUC) that reflect only energy savings and not demand reductions is inappropriate. The LRC used information developed by Working Group 2 of the "Rulemaking on Policies and Practices for Advanced Metering, Demand Response and Dynamic Pricing" in its second report to determine cost effectiveness of a demand response device such as the load shed ballast. (This report is available through the CPUC's web site.) Working Group 2's mission was to develop demand response tariffs and programs and to determine their cost effectiveness.

Based on the methodology presented in the above referenced report, The LRC found the load shed ballast to be cost effective under the high avoided cost case and the retrofit device to not be cost effective under any case.

II. Assumptions

- The demand reduction caused by the load shed ballast or the retrofit device is assumed to be 30 watts per ballast or device. This is based on a three lamp, T-8, electronic ballast light fixture with the ability to reduce power by 30 percent.
- The incremental cost to the customer of a load shed ballast is projected to be $9 over the cost of an instant start ballast. No additional installation costs are included. It is assumed the ballast option would be used when purchasing a new fixture or replacing a failed ballast.

- The cost to the end-use customer of the retrofit device is projected to be $9. Since the retrofit device must be installed in an existing light fixture, an installation fee of $10 per device must be added to the cost.
- Review of all proposed demand reduction tariffs was conducted. For purposes of this determination, Southern California Edison's (SCE) Real Time Pricing, Market Index tariff was chosen. This proposed tariff provides a reasonable payment to the customer and the proposed tariff meets most cost effectiveness tests required by the California Public Utility Commission.
- In determining avoided costs, no externality credits were included for items like reduced emissions, land use and postponements in transmission or distribution construction. The amount of externality credits for demand reduction programs were not available from any resource material. The report from Working Group 2 indicated externalities would be developed as part of their Phase II efforts.

III. Data

All data utilized in determining cost effectiveness were derived from the first and second reports of Working Group 2 on Dynamic Tariff and Program Proposals: Implementation Issues of Docket R.02-06-001 of the California Public Utility Commission (CPUC). These reports can be found on the CPUC web site.

- The total resource cost test in net present value terms produces an equation; Net Present Value Total Resource Cost (NPVTRC) = Utility Avoided Costs (UAC) – Program Administrator Costs (PRC) – Net Participant Costs (PCN).
- The avoided cost of capacity is $85 per kW-yr for the assumption of a new simple cycle gas turbine peaking plant and $10 per kW-yr for an existing peaking plant. The requirement from the Commission was to develop two sets of avoided costs, one using the construction of a new generation unit and the second using an existing peaking generator.
- The discount rate is 9 percent.
- The evaluation horizon is fixed at 11 years.
- The heat rate for a new simple cycle gas turbine is 10,000 Btu per kWh. For an existing peaking plant, the heat rate is 20,000 Btu per kWh. Fuel costs are $3.50 per mmBTU. This amount is held constant for the 11 years.
- SCE's Real Time Pricing Market Index proposed tariff anticipates reducing demand by 4.6 mW at a program cost of $449,000 during year one and $122,000 per year for the remaining ten years.

IV. Total Resource Cost Test

- Utility avoided costs (UAC) are the sum of the net present value of avoided capacity costs plus the avoided fuel costs. There are two UACs that must be considered. The first is a UAC that includes the construction of a new power plant, which is called the high avoided cost case. The second UAC includes the operation of an existing peaking generator that is called the low avoided cost case.

The avoided cost and program administration costs for the load shed ballast and retrofit device are the same.

Net present value of the high avoided cost case UAC is [$85/kW-yr times 0.03 kW (demand reduction of ballast)] plus [3 kWh/yr (energy saved by load shed ballast) times 10,000 Btu/kWh divided by 1,000,000 Btu] times $3.50/mmBtu. The results must be discounted at 9 percent for 11 years.
=$17.35 (net present value of avoided capacity) + $0.71 (net present value of fuel savings)
NPVUAC high avoided cost case = $18.06

Net present value of the low avoided cost case UAC is [$10/kW-yr times 0.03 kW (demand reduction of ballast)] plus [3 kWh/yr (energy saved by load shed ballast) times 20,000 Btu/kWh divided by 1,000,000 Btu] times $3.50/mmBtu. The results must be discounted at 9 percent for 11 years.
=$2.04 (net present value of avoided capacity) + $1.42 (net present value of fuel savings)
NPVUAC low avoided cost case = $3.46

- The total Program Administrator Cost (PRC) for SCE's Real Time Pricing, Market Index proposed tariff is $449,000 for the first year and $122,000 per year thereafter. The program is anticipated to reduce demand by 4.6 mW. Therefore, the net present value of the PRC, for each load shed ballast, is:
  Year 1: [$449,000 divided by 4,600 kW (program demand reduction)] times 0.03kW/ballast = $2.93/ballast
  Years 2-11: [$122,000 divided by 4600 kW] time 0.03 kW/ballast = $0.756/ballast/yr
  The net present value of the PRC is $7.14 for the total 11 years at a 9 percent discount rate.

- The participants net cost (PCN) is the incremental cost of the ballast or the retrofit device plus any incremental installation fees. Payments to the customer to reduce demand are not included in netting customer costs. The inclusion of these payments would have to be offset with a reduction in avoided costs to reflect revenue changes to the utility. These types of calculations are beyond the abilities of this study.
  The PCN for the load shed ballast is $9.
  The PCN for the retrofit device is $9 (materials) + $10 (labor)

- A positive net present value total resource cost (NPVTRC) indicates the technology is cost effective for a utility to consider for its demand response program. A negative NPVTRC says it is a better deal for the utility customers for the utility to purchase the necessary power.

Load Shed Ballast:
NPVTRC High Avoided Cost Case = $18.06 (NPVUAC) - $7.14 (NPVPRC) - $9.00 (PCN). NPVTRC = $1.92
NPVTRC Low Avoided Cost Case = $3.46 (NPVUAC) - $7.14 (NPVPRC) - $9.00 (PCN). NPVTRC = -$12.68

Retrofit Device:
NPVTRC High Avoided Cost Case = $18.06 (NPVUAC) - $7.14 (NPVPRC) - $19.00 (PCN). NPVTRC = -$8.08
NPVTRC Low Avoided Cost Case = $3.46 (NPVUAC) - $7.14 (NPVPRC) - $19.00 (PCN). NPVTRC = -$22.68

- The methodology used for this analysis was verified by conducting the same analysis for the whole of SCE's proposed RTP, market index tariff and comparing the results to that published in the Working Group 2's second report. The results were virtually identical.

V. Conclusions

- The load shed ballast is cost effective under the high avoided cost case.
- The retrofit device is not cost effective under any circumstances.
- The inclusion of externalities is not expected to push the retrofit device into the cost effectiveness realm.
- The inclusion of externalities would provide room for the utility to offer some type of rebate, if they wish, for the load shed ballast.
- Utilities should not promote the use of the retrofit device to their customers because it does not pass the total resource cost test.